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TO: Dr. D. Mills
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A USERS' GROUP FOR UTILITY OPTICAL SENSING APPLICATIONS

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Optical sensors, primarily using optical fibers, are used to measure many parameters of interest to electrical utilities, including physical (temperature, strain), electrical (current, voltage) and chemical. A users' group has been formed to encourage interaction between utilities and manufacturers of optical sensors. The inaugural meeting of this group, the Optical Sensing Manufacturers/Utilities Group (OPSM/UG) was attended.

Optical sensing is a rapidly developing technology that offers potentially great benefits to the electric power industry. In recognition of this, the Electric Power Research Institute (EPRI) has recently featured an article on this subject in its monthly journal/1/ and has sponsored two workshops devoted to the identification of utility needs and manufacturer capabilities in optical sensors. Earlier this year I attended the second of these and presented the results of the generator rotor temperature sensor that we have been developing with EPRI funding/2/. Among the sensors described at this meeting were fiber optic chemical sensors for environmental applications, a fiber optic temperature probe for power transformer winding temperatures, an instrument for monitoring turbine blade temperatures and distributed fiber sensors to measure temperature or strain along a length of fiber, with potential applications in transmission line monitoring.

One factor holding back progress in this field has undoubtedly been the lack of communication between optical sensor manufacturers and the utilities; manufacturers complain that utilities are too conservative and utilities feel that in many cases the manufacturers fail to do adequate market research to uncover their sensor needs. In an effort to overcome these barriers, EPRI has encouraged the formation of a users' group to bring together utility and manufacturer representatives to exchange information, generate ideas for new optical sensor applications and expedite field testing of such sensors. This group, the Optical Sensing Manufacturers/Utility Group (OPSM/UG), held its first meeting October 24, at PSE&G in Newark NJ under the chairmanship of Emile Hyman of the host utility. I was asked to serve as secretary for this

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organization and in that capacity, prepared the meeting minutes, which are given in the Appendix. Detailed summaries of the six technical presentations, which dealt with fiber optic sensors designed to measure current, temperature, vibration and strain, will be sent to members along with the minutes within the next month. I will be glad to circulate this material to anyone who expresses an interest.

As noted in the minutes, OPSM/UG is modeled on a similar group for robotics applications spearheaded by a colleague of Dr. Hyman's. Any member may suggest a topic for discussion or volunteer to present a paper or host a meeting. The robotics group, which began with a similar number of attendees (~50) at its inaugural meeting six years ago, has grown to over 300 members and has played a key role in developing interest in this applications area. EPRI has provided significant support for this organization by, for example, publishing free of charge a recent survey of utility robotic applications and it is expected to assist the optical sensing group in a similar manner. In this regard, it is worth noting that OPSM/UG's third meeting is planned for next August to coincide with the third EPRI-sponsored workshop on utility optical sensing applications. This will be held at EPRI's Monitoring & Diagnostic Center located at a Philadelphia Electric Company fossil station. This facility has not been widely publicized, but represents a good method of obtaining field test data for various sensors and demonstrating them to member utilities.

SUMMARY

The first meeting of the Optical Sensing Manufacturers/Utilities Group (OPSM/UG) attracted nearly 50 attendees, who agreed on a charter and made plans for future meetings. This organization has the potential to improve the interaction between suppliers and users, thereby promoting the use of optical sensors in utility applications.

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1. D. Boutacoff, Optical Sensing for Power Plants, EPRI Journal, pp14-21, September 1990.

2. L. Mannik, Trip Report, EPRI Workshop: Optical Sensing in Utility Applications, May 14-15, 1991; San Francisco, California, OHRD Research Report 91-140-K.

APPENDIX

MEETING MINUTES

FIRST OPTICAL SENSING MANUFACTURERS/UTILITIES GROUP MEETING
OCTOBER 24,1991 - NEWARK, NJ

The inaugural meeting of the Optical Sensing Manufacturers/Utilities Group (OPSM/UG) was hosted by PSE&G in Newark NJ. Emile Hyman began by welcoming the 47 attendees and asking each of them to briefly introduce themselves. The morning was devoted to six technical presentations, summarized below. Details can be found in the attachments to these minutes.

William Morey of United Technologies described a novel type of fiber sensor formed by removing the buffer coating from a low-loss communications fiber and exposing the core to two ultraviolet beams. The resulting interference pattern yields a periodic index of refraction change in the core and this "fiber grating" serves as a wavelength-selective filter in a variety of applications. It can be used directly to measure strain and temperature and, with the addition of an intermediate transducing material, the technique can be also adapted for pressure, vibration, electrical and chemical sensing. These sensors require further development and testing to make them practical devices for utilities.

Robert Einzig of Optical Technologies presented two optical sensors which are already commercially available. An accelerometer based on fiber microbending has given good results in field testing as a seismometer in California. A tachometer which combines an optical fiber with a photoelectric cell has been tested successfully on a nuclear cooling pump. He also described laboratory tests of a fiber optic current sensor using a Rogowski coil and a piezoelectric cylinder. This could be used to replace huge, oil-filled, conventional current transformers; plans for field testing are being discussed with several utilities.

In his presentation, Brent Ware of Amherst International focused on the applications of distributed fiber optic temperature sensing as represented by the system developed by York Sensors. This sensor has been commercially available for over 5 years and has a number of possible utility applications which can take advantage of its ability to determine hot spots along the length of the fiber (up to 20 km). It has already made its way into power transformers, with ABB installing the fiber into their transformer coils. The monitoring of transmission line cables is another potentially attractive application. Many non-utility applications of this sensor were also mentioned, including concrete curing, smart skins for aircraft and fire detection for subways and mines.

Rich Colsher of the EPRI Monitoring and Diagnostic Center gave an overview of the activities of this facility during its 5 years of operation. Located at a Philadelphia Electric Company fossil station (Eddystone), the M&D Center features more than 20 technologies which are applied to monitor the condition of the turbine, generator, boiler and balance-of-plant equipment and

processes. The systems are tied together in a network and serve to demonstrate the benefits of a predictive maintenance program. An average of 6-9 new diagnostic tools are introduced each year and in the next few years there is an intent to select more research-oriented systems. This represents a good opportunity to gain field testing experience with the optical sensors that OPSM/UG is promoting.

The benefits of predictive maintenance using a fiber optic vibration sensor were graphically illustrated by Barry Reichman of PSE&G, who detailed problems with loose stator end windings at one of the utility's 700 MW generators. Without the early detection of problems afforded by this sensor, it is likely that a costly stator winding failure would have occurred. As it was, the vibration monitor, which consists of 6 sensors on each end of the machine, enabled the generator to be shut down in time to repair the unit. In future, this monitor, which costs $250K, will be used on other large units or those that have a history of poor performance.

T.W. Cease of TVA described his utility's experience with optical current transformers. They have been working with ABB, formerly Westinghouse, to develop optical current sensors for 161 kV and 500 kV operation. Interest in optical sensors was accelerated by a series of explosions involving a particular type of oil-filled current transformer. He emphasized the practical difficulties which any new technology must deal with, including a dirty environment (coal dust) which can wreak havoc with electronic equipment and the lack of space for new equipment in a very compact substation. He also brought up the need for NIST standards for optical current transformers. This was echoed by Harold Kirkham of JPL, who discussed some of the issues being wrestled with by an IEEE working group devoted to this task. He welcomed input from anyone wishing to contribute to this effort.

The afternoon session began with a report by Harry Roman of PSE&G on the experience of the Utility/Manufacturers Robot Users' Group (U/MRUG), on which OPSM/UG is modeled. U/MRUG began over 6 years ago with a group similar in size to OPSM/UG and has grown to more than 300 members, of whom approximately 60 attend any given meeting. Every two years the performance and the objectives of the group are critically reviewed. Recently, consideration is being given to formal incorporation, but up to now the business has been handled on a volunteer basis. They have also tried using working groups but found that an informal approach worked best. A continuing concern is how to attract more utility members. A survey of utility robotic applications was recently completed and published by EPRI. Overall, this group has played a pivotal role in creating new opportunities for robotic applications and there is every reason to expect that OPSM/UG will provide similar benefits for optical sensing.

Emile Hyman led a discussion on the wording of the OPSM/UG charter, focusing on the results of a survey of members. The consensus was that the charter would contain the following seven objectives.

1. Discuss optical sensing applications and compile a library/database of actual applications and experience.

2. Provide a forum for outlining utility problem areas and identifying research and development needs; suggest where/how optical sensing might be applied.

3. Recommend utility applications for future use.

4. Develop educational materials for the utility industry which:
   -discuss which optical sensing devices are available today and their applications
   -describe how to evaluate the economics of sensing applications
   -provide basic optical sensing information.

5. Host, conduct and sponsor optical sensing meetings dealing with optical sensing needs, applications, lessons learned and issues impacting commercialization for utility use.

6. Maintain a liaison with optical sensing committees and working groups sponsored by standards-making organizations.

7. Encourage joint development, testing and demonstration of optical sensors for utility applications.

It was decided to limit the thrust of this group to optical sensors, recognizing that this should not be overly restrictive, since it encompasses a wide variety of measurement devices using light. However, there will be discretion to include related technologies or even occasionally non-optical products which an OPSM/UG member may wish to discuss.

All of the suggested activities listed on the survey sheet received broad support. Discussion of additional activities, such as the use of various communications tools, was left to the next meeting. Meetings will be held twice a year, alternating between east and west coasts. Meeting #3 will be held August 25-26, 1992 in Philadelphia in conjunction with an EPRI Workshop on optical sensing. The next meeting is tentatively scheduled for April 14, 1992 in Anaheim to coincide with Sensors Expo West, but a final decision will not be made for a few weeks while Brent Ware waits for members' suggestions regarding other possibilities.

During the course of the afternoon session, it was suggested that we set up a directory of members' present activities in optical sensing. Members are asked to send one-paragraph summaries to Emile Hyman at PSE&G.

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